

**STEIN FINAL EXAM -- BIOLOGY 3058 -- MAY 6, 2011 -- PAGE 1 of 17**

There are 50 questions in this Biology 3058 exam.

All questions are "A, B, C, D, E, F, G, H" questions worth one point each.

There is a total of 50 points in this exam. Fill in your answers on the separate answer sheet.

The format for this exam is:

Fill in A if A is the only correct answer.

Fill in B if B is the only correct answer.

Fill in C if C is the only correct answer.

Fill in D if both A and B are correct (and C is NOT correct).

Fill in E if both A and C are correct (and B is NOT correct).

Fill in F if both B and C are correct (and A is NOT correct).

Fill in G if A and B and C are all correct.

Fill in H if none of the above is correct (A is NOT correct, B is NOT correct, and C is NOT correct).

**ONLY MARK ONE LETTER PER QUESTION.**

You may keep the question sheets.

**Use a dark (black or blue) pencil or dark (black or blue) pen to fill in the answers.**

**DO NOT USE A RED PEN; DO NOT USE A RED PENCIL.**

1. Which of the following serves as an effector, or as part of an effector, that functions in a negative feedback system?
  - A. Ryanodine Receptors in the sarcoplasmic reticulum membranes of rib cage muscles.
  - B. Glycogen Receptors in the plasma membranes of liver cells.
  - C. Glucagon Receptors in the plasma membranes of alpha-islet cells of the pancreas.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
  
2. Which of the following serves as a sensor, or as part of a sensor, that functions in a negative feedback system?
  - A. Peripheral thermoreceptor neurons whose peripheral terminals are located in the skin.
  - B. Calcium-Sensing Receptors (CaSRs) located in the plasma membrane of Parathyroid Gland cells.
  - C. Carotid artery baroreceptor neurons whose central axon terminals are located in the walls of the carotid artery.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
  
3. Which of the following serves as an actuating signal, or as part of an actuating signal, in a negative feedback system?
  - A. Action potentials in the plasma membranes of diaphragm muscle cells.
  - B. Blood plasma levels of glycogen.
  - C. Action potentials in peripheral carotid artery hydrogen-ion-sensitive chemoreceptor neurons.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

4. Which of the following serves as a controlled variable in a negative feedback system?
- A. Temperature levels in the hypothalamus.
  - B. Levels of hydrogen ions in the blood plasma of the carotid artery.
  - C. Blood plasma levels of glucose.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
5. An increase in blood plasma levels of parathyroid hormone
- A. occurs in response to an increase in the levels of calcium ions in blood plasma.
  - B. leads to an increase in the amount of calcium released from the bones into the plasma.
  - C. leads to a decrease in calcium ion excretion in the urine.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
6. At 1 AM, an impermeable membrane separates a 1 liter solution of 1M NaCl in the left compartment from a 1 liter solution containing both 1M NaCl and 1M KCl in the right compartment. At 2 AM, the membrane became permeable to chloride ions. At 4 AM, the membrane once again became impermeable to chloride ions. At 6 AM, the membrane became permeable to sodium ions and, in addition, maintained chloride ion impermeability. At 8 AM, the membrane once again became impermeable to sodium ions. At 10 AM the membrane once again became permeable to chloride ions and, in addition, maintained sodium ion impermeability. The membrane maintained impermeability to potassium ions during the entire period.
- A. The amount of sodium ions in the left compartment at 7 AM will be less than the amount of sodium ions in the left compartment at 5 AM.
  - B. The amount of chloride ions in the left compartment at 11 AM will be less than the amount of chloride ions in the left compartment at 5 AM.
  - C. The amount of chloride ions in the left compartment at 11 AM will be equal to the amount of chloride ions in the right compartment at 11 AM.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
7. Which of the following is true for endocytosis?
- A. During endocytosis of GLUT4 transporters in fat cells, there is removal of GLUT4 transporters from plasma membranes.
  - B. During endocytosis of GLYCOGEN2 transporters in liver cells, there is removal of GLYCOGEN2 transporters from plasma membranes.
  - C. During endocytosis of AQP2 channels in epithelial cells in the kidney medullary collecting duct, there is removal of AQP2 channels from luminal membranes.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

8. Which of the following is true for the sodium-potassium pump ATPase?
- A. There is a net flux of sodium from intracellular spaces into luminal spaces via sodium-potassium pump ATPase spanning proteins located in the luminal membranes of epithelial cells in the medullary collecting duct of the kidney.
  - B. There is a net flux of sodium from intracellular spaces into extracellular spaces via sodium-potassium pump ATPase spanning proteins located in the plasma membranes of toe motor neurons.
  - C. There is a net flux of sodium from cytosol near troponin molecules into the internal spaces of the sarcoplasmic reticulum via sodium-potassium pump ATPase spanning proteins located in the sarcoplasmic reticulum membranes of diaphragm muscles.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
9. Which of the following is true for a G-protein?
- A. When an agonist binds to the binding site of a G-protein-coupled receptor (GPCR), this leads to GTP displacing a GDP bound to the alpha subunit of the G-protein.
  - B. When an antagonist binds to the binding site of a G-protein-coupled receptor (GPCR), this has no effect on the GDP that is bound to the alpha subunit of the G-protein.
  - C. When GTP binds to an alpha subunit of the G-protein, this leads to the alpha subunit of the G-protein dissociating from the beta and gamma subunits of the G-protein.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
10. Which of the following occur in response to an increase in the length of the right knee extensors in response to a quick tap applied to the right patellar tendon? An increase in the amount of
- A. open channels associated with AMPA receptors in the plasma membranes of the right knee extensor muscle fibers.
  - B. calcium conductance in the axonal endings of the right knee extensor motor neurons.
  - C. open force-gated channels in the central axon terminals of IA muscle-spindle stretch receptor neurons whose peripheral terminals are in the right knee extensor muscle.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

11. Consider a system that contains three neurons in a culture dish bathed in normal physiological saline. All three neurons are healthy. Neuron A synapses onto Neuron B. Neuron B synapses onto Neuron C. Neuron A has glycine in its synaptic vesicles. Neuron B has GABA in its synaptic vesicles. The only ligand-gated receptors in Neuron A are AMPA channels. The only ligand-gated receptors in the plasma membrane of Neuron B are glycine receptors. The only ligand-gated receptors in the plasma membrane of Neuron C are GABA<sub>B</sub> receptors. All 3 neurons have no other ligand-gated receptors in their plasma membranes. All 3 neurons have a sodium equilibrium potential of +60 millivolts. All 3 neurons have a potassium equilibrium potential of -86 millivolts. All 3 neurons have a chloride equilibrium potential of -20 millivolts. The threshold for an action potential in all 3 neurons is -55 millivolts. At 1:55 AM, glutamate is added to the physiological saline. At 2:00 AM, the action potential firing rate of each neuron is 100 Hz. Which of the following will lead to a decrease in Neuron C's action potential firing rate?
- A. At 2:01 AM, glycine is added to the bath.
  - B. At 2:01 AM, strychnine is added to the bath.
  - C. At 2:01 AM, CNQX is added to the bath.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
12. Which of the following are true?
- A. Nicotine is an agonist both at the muscarinic ACh receptor and at the nicotinic ACh receptor.
  - B. Consider the channel associated with the GABA<sub>B</sub> receptor and the channel associated with the glycine receptor. For both types of channel, there is a chloride conductance greater than zero when the channel is open.
  - C. Consider the channel associated with the muscarinic ACh receptor and the channel associated with the nicotinic ACh receptor. For both types of channel, there is a potassium conductance greater than zero when the channel is open.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

13. Neuron A is a healthy neuron with all the usual ion channels. When at rest with a membrane voltage of R millivolts, neuron A produces no action potentials. The voltage threshold for an action potential in neuron A is T millivolts. T is greater than R; T is less than zero. In addition, neuron A's membrane includes the membrane-spanning molecule Z with an ion channel that opens when neurotransmitter Y binds to the Y receptor site on the extracellular surface of Z. The Nernst equilibrium potential for Z's ion channel is E millivolts. Neuron B synapses on neuron A; neuron B's neurotransmitter is neurotransmitter Y. Which of the following statements are true when neuron A is initially at rest and neuron B releases neurotransmitter Y?
- A. If the value of E is equal to R, and if chloride is the only ion that passes through open Z channels, then Y's binding to its receptor site on Z in neuron A produces no change in the amount of intracellular chloride ions in neuron A.
  - B. If the value of E is equal to R, and if chloride is the only ion that passes through open Z channels, then Y's binding to its receptor site on Z in neuron A produces no change in the chloride conductance of the plasma membrane of neuron A.
  - C. If the value of E is zero and if both sodium ions and potassium ions pass through open Z channels, then Y's binding to its receptor site on Z in neuron A produces no change in the amount of intracellular sodium ions in neuron A.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
14. Consider four culture dishes; each dish has one healthy neuron in it. Dish W has Neuron W in it; Dish X has Neuron X in it; Dish Y has Neuron Y in it; and Dish Z has Neuron Z in it. At 1:00 AM: each neuron is bathed in normal physiological saline; all the neurons have the same properties; and each neuron is at rest with a resting potential of -70 millivolts. Each neuron has only three types of ionotropic ligand-gated receptors: AMPA Receptors, NMDA Receptors, and Glycine Receptors. None of the neurons have metabotropic receptors. Each neuron has a chloride equilibrium potential of -80 millivolts. At 1:55 AM, a large amount of TTX is added to the physiological saline in all four dishes. Ignore any effects due to voltage-gated calcium channels with S4 helices. At 1:58 AM, the amount of intracellular calcium in each neuron is the same as that of each other neuron. For each neuron, define MAXV as the maximum voltage that is reached by that neuron during the period from 2:00 AM to 2:02 AM. At 2:00 AM:
- glutamate and APV are added to the physiological saline of Dish W;
  - glutamate and CNQX are added to the physiological saline of Dish X;
  - glutamate and glycine are added to the physiological saline of Dish Y;
  - glutamate, glycine, and strychnine are added to the physiological saline of Dish Z.
- A. At 2:01AM, the total sodium conductance in Neuron X is greater than the total sodium conductance in Neuron Y.
  - B. At 2:01 AM, the total calcium conductance in Neuron Y will be greater than the total calcium conductance in Neuron Z.
  - C. At 2:01AM, the MAXV in Neuron W is less than the MAXV in Neuron X.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

15. Consider Neuron B in the frog central nervous system whose plasma membrane has a newly discovered ligand-gated ionotropic receptor, named the LGD receptor. The channel in the same molecular complex as the LGD receptor is termed the LGD receptor channel and is a monovalent cation channel that, when open, is permeable to both sodium and potassium. The Nernst equilibrium potential for sodium in Neuron B is +50 mV, and the Nernst equilibrium potential for potassium in Neuron B is -100 mV. The threshold for an action potential in Neuron B is -55 mV and the resting potential for Neuron B is -75 mV. LGD is an agonist for the ligand-gated ionotropic receptor. When LGD binds to its binding site, there is an increase in conductance of both sodium and potassium in the LGD receptor channel. Neuron A synapses onto Neuron B. Neuron A's transmitter is LGD.
- A. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals three times its sodium conductance. For this situation, in response to an action potential in Neuron A, then there will be a voltage increase and an excitatory postsynaptic potential in Neuron B.
  - B. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals four times its sodium conductance. For this situation, in response to an action potential in Neuron A, then there will be no change in voltage in Neuron B.
  - C. Consider the situation that when the LGD receptor channel is open in Neuron B, its potassium conductance equals nine times its sodium conductance. For this situation, in response to an action potential in Neuron A, then there will be a voltage decrease and an inhibitory postsynaptic potential in Neuron B.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
16. Which of the following is true for primary motor cortex (M1) corticospinal interneuron A that produces action potentials during movements of the big toe of the left foot in right-handed Patient X who has a complete transection of the corpus callosum.
- A. In Patient X, the cell body of interneuron A is located in between the central sulcus of the right cerebral cortex and the right eye.
  - B. The axon terminals of interneuron A are located on the left side of Patient X's spinal cord.
  - C. Interneuron A will increase its action potential firing rate after Patient X reads the statement "Wiggle the big toe of your left foot" presented in Patient X's right visual field.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
17. Which of the following is an antagonist that binds to the receptor site that is part of a ligand-gated ionotropic ion channel?
- A. strychnine.
  - B. curare.
  - C. TTX (tetrodotoxin).
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

18. Consider Neuron B in the frog central nervous system whose plasma membrane has a previously unknown channel that is selectively conductive to a newly discovered tetravalent anion named TRVA with a valence of -4. The threshold for an action potential in Neuron B is -65 millivolts and the resting potential for Neuron B is -70 millivolts. The TRVA channel in Neuron B is part of an ionotropic receptor with an extracellular binding site for the newly discovered ligand LGD. When LGD binds to its binding site, there is an increase in the TRVA conductance of Neuron B. Neuron A synapses onto Neuron B. Neuron A's neurotransmitter is LGD.
- A. Consider the situation that the extracellular concentration of TRVA is 10,000 times greater than the intracellular concentration of TRVA. For this situation, in response to an action potential in Neuron A, there will be an increase in the membrane voltage of Neuron B and an inhibitory postsynaptic potential in Neuron B.
  - B. Consider the situation that the extracellular concentration of TRVA is 10,000 times greater than the intracellular concentration of TRVA. For this situation, in response to an action potential in Neuron A, there will be a decrease in the amount of intracellular TRVA in Neuron B.
  - C. Consider the situation that the extracellular concentration of TRVA is 100,000 times greater than the intracellular concentration of TRVA. For this situation, in response to an action potential in Neuron A, there will be an increase in the amount of intracellular TRVA in Neuron B and an inhibitory postsynaptic potential in Neuron B.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
19. Consider an axon of a neuron. At time= $t_1$ , its voltage is at threshold for an action potential; at time= $t_2$ , its voltage is at 0 millivolts prior to the peak of that action potential. In the time period between  $t_1$  and  $t_2$  of that single action potential,
- A. sodium conductance of the voltage-gated sodium channels decreases as membrane voltage increases.
  - B. sodium conductance of the voltage-gated sodium channels changes with a slower time course than potassium conductance of the voltage-gated potassium channels.
  - C. the amount of intracellular sodium decreases.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

20. A complete motor neuron is removed from a frog and placed in normal physiological saline at 1 AM. The neuron is healthy. At 2 AM, the physiological saline bathing the neuron is removed and replaced with a modified physiological saline. The composition of the modified physiological saline is as follows: its potassium concentration is the same as normal physiological saline; its sodium concentration is the same as the intracellular sodium concentration of the motor neuron; its total concentration of solutes (osmolarity) is the same as normal physiological saline. For this question, ignore any possible effects due to the sodium-potassium pump. At 2:05 AM, the resting membrane voltage of the neuron is -70 millivolts. At 2:06 AM,
- A. the value of the Nernst equilibrium potential for sodium ions for the neuron is greater than +20 millivolts.
  - B. an increase in sodium conductance will lead to an increase in the amount of intracellular sodium.
  - C. an increase in sodium conductance will lead to an increase in the membrane voltage.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
21. A healthy skeletal muscle fiber is isolated and has no external forces on it. It has normal intracellular levels of ATP and is bathed in physiological saline. Which of the following will lead to an increase in the overlap between thin and thick filaments in the muscle fiber?
- A. An increase in the amount of binding of curare to the nicotinic Acetylcholine Receptors (nAChRs) on the surface of the skeletal muscle.
  - B. An increase in the amount of calcium ions bound to troponin.
  - C. A decrease in the calcium conductance of the membranes of the sarcoplasmic reticulum.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
22. Which of the following is true in a skeletal muscle?
- A. The binding of calcium ion to a binding site on the troponin molecule leads to a movement of the tropomyosin molecule that, in turn, exposes a binding site on the actin molecule for ATP.
  - B. The head of a myosin molecule is activated (energized) during the hydrolysis of ATP (which is bound to the myosin head) to cAMP and  $P_i$ .
  - C. Consider the situation in which a myosin head is attached to its receptor site on the actin molecule. For this situation, the binding of ATP to a binding site on the myosin head causes detachment of the myosin head from the actin molecule.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.



23. Which of the following is true for exocytosis in a skeletal muscle?
- A. During exocytosis in a skeletal muscle, there will be release of calcium ions from intracellular vesicles in the sarcoplasmic reticulum in response to high levels of Ryanodine binding to Ryanodine Receptors in the transverse tubules.
  - B. During exocytosis in a skeletal muscle, there will be insertion of GLUT4 transporters into the plasma membrane in response to Insulin binding to Insulin Receptors in the plasma membrane.
  - C. During exocytosis in a skeletal muscle, there will be release of acetylcholine (ACh) from the sarcoplasmic reticulum into the cytosol.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
24. When the overlap between the thin and thick filaments of a sarcomere in a skeletal muscle is decreasing,
- A. the total length of the I band is increasing in the sarcomere.
  - B. the length of H zone is increasing in the sarcomere.
  - C. the length of the A band minus the length of the H zone is decreasing in the sarcomere.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
25. Starting at 1 AM, you record the firing frequency of the axons of carotid artery baroreceptors as well as the blood pressure in the carotid artery. At 2 AM, you directly apply chemical Z to all the axons of the carotid artery baroreceptors at location L in a peripheral nerve at a place that is midway between the baroreceptor peripheral terminals and the baroreceptor central axonal terminals. You discover that chemical Z induces a previously unknown lowering of the excitability of the axon with the following property: for every two action potentials produced between baroreceptor peripheral terminals and location L, there is one action potential produced between location L and baroreceptor central axonal terminals. Thus, chemical Z causes a reduction of the rate of firing of carotid baroreceptors as action potentials pass location L; only one-half of the action potentials initiated in the peripheral terminals propagate all the way to the central axonal terminals.
- A. At 2:10 AM, the parasympathetic output to the heart will be higher than at 1:50 AM.
  - B. At 2:10 AM, blood pressure will be higher than at 1:50 AM.
  - C. At 2:10 AM, arteriolar diameters will be smaller than at 1:50 AM.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

26. Consider a system that contains a healthy SA node cell in a culture dish bathed in normal physiological saline. The SA node cell contains all of the usual molecules. You use a technique to measure  $G_F$ -channel (F-channel conductance) when the membrane of the SA node cell is held at a constant voltage of -75 millivolts starting at 1:55 AM. The technique allows you to keep the SA node cell at that voltage for 10 minutes. You also have the ability to control directly the intracellular amounts of cAMP. You can also add substances to the extracellular saline bathing the SA node cell. At 2:00 AM, you measure  $G_F$ -channel.
- A. At 2:01 AM, norepinephrine is added to the physiological saline.  
This will lead to an increase in  $G_F$ -channel compared with its 2:00 AM value.
  - B. At 2:01 AM, ACh (acetylcholine) is added to the physiological saline.  
This will lead to a decrease in  $G_F$ -channel compared with its 2:00 AM value.
  - C. At 2:01 AM, there is a decrease in the intracellular amount of cAMP.  
This will lead to a decrease in  $G_F$ -channel compared with its 2:00 AM value.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
27. Which of the following is true for the ATP-sensitive potassium channel?
- A. In smooth muscle cells surrounding an arteriole serving a region of the body that has just recently had very high levels of cellular activity, the potassium conductance of the ATP-sensitive potassium channels in the plasma membranes of these smooth muscle cells will be very high.
  - B. The channel is a spanning protein with a receptor site for ATP located on an extracellular region of the protein.
  - C. When blood plasma levels of glucose are very high, the potassium conductance of the ATP-sensitive potassium channels in the plasma membranes of beta-islet cells will be very high.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
28. Which of the following will lead to an increase of total peripheral resistance?
- A. A decrease in the diameter of every arteriole.
  - B. An increase of sympathetic discharge to all the smooth muscles that surround the arterioles.
  - C. An increase in the firing frequency of all the carotid artery baroreceptors.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

29. Which of the following are true for the SA node cardiac muscle cells?
- A. An increase in the binding of norepinephrine to beta-adrenergic receptors in the plasma membranes of SA node cells will lead to an increase in heart rate.
  - B. F-channel conductance will increase only when SA node cell membrane voltage is greater than -40mv.
  - C. An increase in the binding of acetylcholine to nicotinic ACh receptors in the plasma membranes of the SA node cells will lead to a decrease in heart rate.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
30. Erythropoietin (EPO)
- A. is secreted by peritubular interstitial cells of the kidney cortex.
  - B. acts by increasing the production of red blood cells by cells in the liver.
  - C. levels in the blood plasma serve as an actuating signal in a long-term negative feedback loop that controls the amount of oxygen in the peritubular interstitial spaces of the kidney cortex.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
31. Which of the following serves as an effector, or as part of an effector, in a negative feedback system?
- A. Sodium-potassium ATPase pumps in the plasma membranes of rib cage inspiratory muscles.
  - B. Binding sites for calcium ions on tropomyosin molecules in rib cage expiratory muscles.
  - C. GLUT4 transporters in the diaphragm muscle.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
32. Which of the following processes in capillaries in the lung assist in the removal of carbon dioxide from the body?
- A. Net flux of carbon dioxide from red blood cells into plasma.
  - B. Net flux of bicarbonate from plasma into red blood cells.
  - C. Formation of carbonic acid by carbonic anhydrase in red blood cells.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

33. Which of the following processes help bring oxygen to the body cells that are in a leg?
- A. Removal of oxygen from hemoglobin in response to high (that is, greater than 80 mmHg) partial pressures (concentration) of oxygen in red blood cells in the leg.
  - B. An increase in the amount of HbRH (Hemoglobin Releasing Hormone) that is bound to HbRH Receptors in the plasma membrane of the red blood cell.
  - C. An increase in hydrogen ion concentration in red blood cells in the body capillaries in the leg.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
34. Which of the following is true?
- A. Blood plasma entering the lungs has a greater amount of bicarbonate ions than blood plasma leaving the lungs.
  - B. Red blood cells in blood entering the lungs have a lower percentage of hemoglobin oxygen-binding sites occupied with oxygen than red blood cells in the blood leaving the lungs.
  - C. Red blood cells in blood entering the lungs have a greater amount of hydrogen ions bound to hemoglobin than red blood cells in blood leaving the lungs.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
35. Which of the following are true for ventilation?
- A. An increase in the hydrogen ion concentration in the interstitial spaces of the brain stem leads to an increase in the duration of the respiratory cycle (duration of respiratory cycle equals duration of inspiration plus duration of expiration).
  - B. An increase in the pressure within the chest cavity results in the inspiration of air into the lungs.
  - C. The problems with ventilation induced by injection of curare occur because of the drug's direct action on the mAChRs (muscarinic Acetylcholine Receptors) in the plasma membranes of the diaphragm skeletal muscle and the rib-cage skeletal muscles.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

36. From March 1 to March 31, Healthy Person W ate a normal diet with normal amounts of food and water. From April 1 to April 30, Healthy Person W was on a diet that consisted of normal amounts of food and very small amounts of water.
- A. April 15 values of the concentration of dissolved solutes in W's urine were lower than March 15 values of the concentration of dissolved solutes in W's urine.
  - B. April 15 values of W's water permeability across the luminal membranes of the medullary collecting duct epithelial cells were higher than March 15 values of W's water permeability across the luminal membranes of the medullary collecting duct epithelial cells.
  - C. April 15 values of W's blood plasma levels of vasopressin were higher than March 15 values of W's blood plasma levels of vasopressin.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
37. Which of the following is a situation in which a closed loop negative feedback system is converted to an open loop system?
- A. A disease that destroys all the adenylyl cyclase and all the cAMP in the intracellular spaces of all the epithelial cells of the medullary collecting duct.
  - B. A disease that destroys all the G-proteins in all the epithelial cells of the medullary collecting duct.
  - C. A disease that destroys all the AQP2 Receptors in the basolateral membranes of all the epithelial cells of the medullary collecting duct.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
38. Which of the following is true for the epithelial cells of the kidney proximal tubule?
- A. The sodium-glucose co-transporter in the luminal membrane is responsible for the net flux of glucose from luminal space to intracellular space.
  - B. The sodium-potassium pump in the basolateral membrane is responsible for the net flux of sodium from intracellular space to interstitial space.
  - C. The GLUT2 transporter in the basolateral membrane is responsible for the net flux of glucose from intracellular space to interstitial space.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

39. A new drug named ANTI-V2R has been developed that is a V2 receptor antagonist. When ANTI-V2R binds to a V2 receptor, there is no binding of vasopressin to that V2 receptor and there is no activation of G proteins. ANTI-V2R will help relieve some of the problems for which of the following patients?
- A. A patient with nephrogenic diabetes insipidus caused by a mutation in the AQP2-channel gene.
  - B. A patient whose blood plasma vasopressin levels are always very high due to a tumor whose cells are vasopressin-containing neurosecretory cells that continuously secrete high levels of vasopressin into the blood plasma.
  - C. A patient with neurogenic diabetes insipidus who produces no vasopressin.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
40. Healthy Person P takes a new drug that is a member of a drug family that results in constant levels of cytosolic cyclic AMP (cAMP) in one and only one cell type in the body. A single dose of each member of the new drug family works within one hour and lasts for one week. Which of the following is true for P one day after taking a specific member of the new drug family?
- A. Consider the situation that P takes Drug A that produces constant very low levels of cytosolic cAMP in the epithelial cells of the medullary collecting duct of the kidney. One day after taking Drug A, the water permeability of the luminal membranes of these cells in P will be higher than pre-drug levels.
  - B. Consider the situation that P takes Drug B that produces constant very low levels of cytosolic cAMP in the SA node cells of the heart. One day after taking Drug B, P's heart rate will be higher than pre-drug levels.
  - C. Consider the situation that P takes Drug C that produces constant very high levels of cytosolic cAMP in the cells of the liver. Ignore any effects due to insulin binding to insulin receptors in the liver. One day after taking Drug C, the amount of glycogen in P's liver cells will be higher than pre-drug levels.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
41. Which of the following assist in the digestion of fats?
- A. Production of bile salts in the liver and the secretion of those bile salts into the small intestine.
  - B. Production of lipase in the pancreas and secretion of lipase into the lumen of the small intestine.
  - C. Emulsification of fats into droplets by bile salts in the lumen of the small intestine.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

42. Person X is a healthy human who has volunteered to take experimental drug Y. Person X has a normal dinner at 6 PM on April 1 and then does not eat for 12 hours. At 5 PM on April 2, X takes a dose of Y that opens all the ATP-sensitive potassium channels in X's beta-islet cells of the pancreas for 12 hours. Person X has a normal dinner at 6 PM on April 2 and then does not eat for 12 hours. For this question, ignore any effects due to alpha-islet cells of the pancreas.
- A. At 8 PM on April 2, the glucose permeability of the plasma membranes of X's skeletal muscle cells will be higher than the glucose permeability of the plasma membranes of X's skeletal muscle cells at 8 PM on April 1.
  - B. At 8 PM on April 2, X's blood plasma levels of glucose will be higher than X's blood plasma levels of glucose at 8 PM on April 1.
  - C. At 8 PM on April 2, X's blood plasma levels of insulin will be higher than X's blood plasma levels of insulin at 8 PM on April 1.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
43. Which of the following is true?
- A. Binding of GH (Growth Hormone) to GH Receptors (Growth Hormone Receptors) located in the plasma membranes of cells in the anterior pituitary leads to the secretion of GHRH (Growth Hormone Releasing Hormone) from the anterior pituitary into the blood plasma.
  - B. GHRH Receptors (Growth Hormone Releasing Hormone Receptors) are located only in the plasma membranes of cells in the hypothalamus.
  - C. GHRH (Growth Hormone Releasing Hormone) travels in specialized capillaries located in the pituitary stalk between the hypothalamus and the anterior pituitary.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
44. Which of the following is true?
- A. Insulin binding to Insulin Receptors in the plasma membranes of liver cells leads to an increase in intracellular levels of Glycogen in the liver cells.
  - B. Glucagon binding to Glucagon Receptors in the plasma membranes of liver cells leads to a decrease in intracellular levels of cAMP in the liver cells.
  - C. Insulin binding to Insulin Receptors in the plasma membranes of diaphragm muscle cells leads to an increase in the exocytosis of GLUT4 transporters into the sarcoplasmic reticulum membranes of the diaphragm muscles.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.

45. Which of the following is true?
- A. GLUT2 transporter molecules are responsible for the net flux of glucose from the interstitial spaces surrounding beta-islet cells of the pancreas into the intracellular spaces of beta-islet cells of the pancreas.
  - B. GLUT2 transporter molecules are responsible for the net flux of glucose from the interstitial spaces of the kidney cortex into the intracellular spaces of proximal tubule epithelial cells.
  - C. When blood plasma levels of glucagon are high and blood plasma levels of insulin are low, GLUT2 transporter molecules are responsible for the net flux of glucose from the intracellular spaces of liver cells into the interstitial spaces surrounding liver cells.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
46. During a fever in a human,
- A. shivering may occur when the actual body temperature is lower than the set point for body temperature during the fever.
  - B. there is an increase in the value of the set point for body temperature when compared with the value of the set point for body temperature when that person was healthy prior to the fever.
  - C. the control system for body temperature functions as a closed-loop positive-feedback system.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
47. Healthy human female X is 25 years old and not pregnant. During the postovulatory phase of X's menstrual cycle,
- A. there are high blood plasma levels of LH and FSH.
  - B. there are high blood plasma levels of hCG (human Chorionic Gonadotropin).
  - C. the corpus luteum releases high levels of estrogen and progesterone into the blood plasma.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.



48. Z is a healthy adult female who ovulates in each menstrual cycle; Z is not pregnant. During Z's menstrual cycle, high blood plasma levels of progesterone
- A. occur just prior to ovulation.
  - B. occur just after menstruation.
  - C. occur only when blood plasma levels of estrogen are very low.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
49. A complex question is flashed on a screen in the left visual field of right-handed Person Z. Z is a healthy individual with a normal nervous system. Z has a patch over Z's right eye so that Z sees the question only in Z's left eye.
- A. The stimulus of flashing the question will excite neurons in Z's right primary visual cortex (V1).
  - B. The stimulus of flashing the question will excite neurons in the left half of Z's left retina.
  - C. Z will understand the meaning of the question and generate a correct oral answer only after some of the axons in the corpus callosum generate action potentials.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.
50. Right-handed adult patient X with a complete transection of the corpus callosum is presented with a simple written question in X's right visual field. A barrier is positioned so that patient X can see his right hand only in his right visual field and his left hand only in his left visual field. Patient X will be
- A. able to use his left hand to move scrabble tiles (pieces of wood with letters on them) so that he spells out the correct answer with his left hand.
  - B. able to respond correctly to the sentence with a verbal reply.
  - C. able to use a pencil in his right hand to spell out the correct answer on a piece of paper.
  - D. A and B.
  - E. A and C.
  - F. B and C.
  - G. A, B, and C.
  - H. None of the above.